Radio Science Support

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Since 1967, radio scientists have used the Deep Space Network 26- and 64-m-diameter antenna stations to investigate pulsars, to study the effect of solar corona on radio signals, and to observe radio emissions from X-ray sources. More recently, very long baseline interferometry (VLBI) techniques have been used for high-resolution studies of quasars. During the reporting period, VLBI observations were made of quasars and also of the Mariner 9 spacecraft. Support was also provided by the 64-m-diameter antenna for the measurement of cosmic background noise.

I. Introduction

The 26- and 64-m-diameter antenna stations of the DSN have been used for several years to support radio science experiments. NASA, JPL, and university scientists have used key DSN facilities whose particular and unique capabilities were required for the performance of the experiments. In order to formalize the method of selecting experiments and experimenters, a Radio Astronomy Experiment Selection (RAES) Panel was formed in 1969. Notice of availability of these facilities was placed in professional journals to inform the scientific community that they were available for limited use by qualified radio scientists (Ref. 1). No charge is made for use of the standard DSN facilities and equipment; special equipment, however, must be provided by the experimenters. A summary of all experiments conducted through December 1971 is reported in Refs. 2, 3, 4, and 5.

II. Radio Science Operations

Table 1 shows experiments supported in January and February 1972. The observations at 13 cm and 3 cm by the National Radio Astronomy Observatory (NRAO)–Cornell–Caltech group make use of the 64-m-diameter antenna at Goldstone, California (DSS 14) and the 37-m-diameter antenna at the Massachusetts Institute of Technology (MIT) Haystack Observatory. These observations have resulted in a number of articles identified in Refs. 2 and 5. Reference 6 is an article previously overlooked in these reports.

The observations by the Goddard Space Flight Center (GSFC)–JPL–MIT–University of Maryland group are a continuation of earlier work, the published results of which are identified in Refs. 2, 3, and 5. These observations resulted in the initial report of the apparent anoma-

lous expansion rate of Quasars 3C279 and 3C273 (Ref. 7). The NRAO–Cornell–Caltech group confirmed the observations. These topics were discussed at the meeting of the American Astronomical Society in San Juan, Puerto Rico, December 5–8, 1971 (Ref. 5).

Measurements of the cosmic background radiations at 3.5 cm were made by Carpenter, Gulkis, and Sato. These are the initial measurements made by this group since approval of the experiment in the September–October 1971 reporting period. Use of the 64-m-diameter antenna has been preempted by *Mariner* 9 until recently. Availability of the antenna has also permitted resumption of VLBI measurements at 13 cm using the trans-Pacific baseline between Goldstone and the 26-m-diameter antenna at Woomera, Australia. Results of previous measurements on this baseline have been published (Ref. 8). The Australian experimenters have also used the Woomera antenna in coordination with observations made from the 26-m-diameter dish near Johannesburg, South Africa. These observations on a trans-Indian Ocean baseline were made under the auspices of South African and Australian agencies under arrangements whereby they may utilize the antennas when not required for support of NASA programs.

III. RAES Panel Activities

The Radio Astronomy Experiment Selection Panel approved three experiments during the reporting period (Table 2).

IV. OSS Program Support

The DSN also provides support and use of the facilities for radio science programs of the NASA Office of Space Sciences (OSS). As reported in Ref. 4, feasibility was demonstrated in October of 1971 of tracking the *Mariner* 9 spacecraft by VLBI techniques. In the demonstration, the Goldstone 26-m Echo station and the 64-m Mars station were equipped with JPL hydrogen maser frequency systems and operated electrically independent, although with coordinated observing modes. As shown in Table 1, such observations were repeated using the 64-m-diameter antenna at Goldstone and the 26-m-diameter antenna at Woomera, Australia. The observations were made successfully and the data are now being processed.

V. NASA Radio Science Plan Support

In January, the Laboratory forwarded to the NASA Radio Science Panel inputs to the annual Radio Science Plan being formulated by the Panel. The submission included all experiments currently approved by the RAES Panel, the descriptions and requirements of all OSS Program Radio Science experiments, and, for information, the descriptions of the DSN Development activities that produce radio science data. The latter are planetary radar experiments conducted in the development of advanced high-power transmitters, improved-stability frequency systems, etc.

References

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3. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. V, pp. 42–44. Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1971.

4. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. VI, pp. 43–45. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1971.

5. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. VII, pp. 29–31. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1972.

6. Cohen, M. H., and Shaffer, D. B., "Positions of Radio Sources from Long-Baseline Interferometry," *Astron. J.,* Vol. 76, No. 2, pp. 91–100, Mar. 1971.

7. Shapiro, I., et al., "Quasars: Millisecond of Arc Structure Revealed by Very Long Baseline Interferometry," *Science,* Vol. 172, p. 52, Apr. 2, 1971.

8. Gubbay, J. S., et al., "The Structure of P1934-63," *Astron. J.,* Vol. 76, No. 10, pp. 965–969, Dec. 1971.

Table 1. Radio science experiments involving 64- and 26-m-diameter antenna facilities

Experiment	Purpose	Experimenter	DSN facility	Date
X-band VLBI	To study the structure of extra galactic sources with improved resolution.	J. Broderick (NRAO) B. Clark (NRAO) K. Kellermann (NRAO) D. Jauncey (Cornell University) M. Cohen (Caltech) D. Shaffer (Caltech)	DSS 14 (and MIT Haystack Antenna)	Feb. 1971 Nov. 2, 1971 Feb. 5, 1972
Quasar structure by X-band VLBI	To monitor time variations and fine structure and apparent position of quasars.	T. Clark (GSFC) R. Goldstein (JPL) H. Hinteregger (MIT) C. Knight (MIT) G. Marandino (Univ. of Maryland) A. Rogers (MIT Haystack Observatory) I. Shapiro (MIT) D. Spitzmesser (JPL) A. Whitney (MIT)	DSS 14 (and MIT Haystack Antenna)	June 9 and 19, 1971 Sept. 19, 1971 Oct. 2–4, 10, 17, 1971 Jan. 4, 1972 Feb. 18, 1972
Small-scale variations in cosmic background radiation.	Search for small-scale spatial variations in the 2.7 K cosmic background radiation of 3.5 cm	R. Carpenter (Calif. State College, Los Angeles) S. Gulkis (JPL) T. Sato (JPL)	DSS 14	Jan. 10 and 11, 1972 Feb. 11, 12, and 22, 1972
Very long baseline interferometry (medium data bandwidth, S-band)	To determine angular size of radio sources	J. Gubbay (Univ. of Adelaide) A. Legg (Space Research Group, WRE) D. Robertson (Space Research Group, WRE) A. Moffett (Caltech) B. Seidel (JPL)	DSSs 14 and 41	June 12, 1971 Jan. 25, 1972 Feb. 21, 1972
Mariner 9/extra-galactic source VLBI	To locate *Mariner 9* spacecraft with respect to well-known quasars at 2300 MHz.	P. MacDoran (JPL)	DSSs 14 and 41	Jan. 17, 20, and 25, 1972
Indian Ocean baseline VLBI	To study structure of selected quasars and galaxies at 2300 MHz.	G. Nicholson (National Institute of Telecommunications Research, South Africa) D. Robertson [Weapons Research Establishment (WRE), Australia]	DSS 41 (26-m) DSS 51 (26-m)	Jan. 21, 1972 Feb. 14, 1972

Table 2. Recent experiments approved by the RAES panel

Experiment	Purpose	Experimenters	DSN facility
Weak radio source observations	To measure the "confusion distribution" of weak radio sources at 2.3 GHz.	D. L. Jauncey (Cornell University) M. J. Yerbury (Cornell University) J. J. Condon (Cornell University) D. J. Spitzmesser (JPL)	64-m-diam antenna (DSS 14) at Goldstone
Transcontinental baseline VLBI	To measure transcontinental vector baselines by VLBI observation of quasars.	T. A. Clark (GSFC) H. F. Hinteregger (MIT) C. A. Knight (MIT) S. Lippincott (MIT Haystack Observatory) A. E. Rogers (MIT Haystack Observatory) I. I. Shapiro (MIT) A. R. Whitney (MIT)	64-m-diam antenna (DSS 14) at Goldstone with hydrogen maser [Also MIT Haystack 37-m-diam antenna and National Oceanic and Atmospheric Administration (NOAA) 26-m-diam antenna in Alaska]
Pulsar observations	To measure position and apparent motion of pulsars at 2.3 GHz by VLBI.	T. A. Clark (GSFC) G. S. Downs (JPL) N. C. Erickson (University of Maryland) P. E. Reichley (JPL) N. R. Vandenberg (University of Maryland)	64-m-diam antenna (DSS 14) at Goldstone. 26-m for feasibility. (Also NRAO 42-m-diam antenna at Greenbank, West Virginia)